Recording methods and devices for recording information on dual layer recordable disks

The invention relates to recording methods for recording information on a dual layer recordable disk, the methods comprising a step of performing an Optimum Power Control (OPC) procedure for determining an actual optimum writing power, said Optimum Power Control procedure being performed in an OPC-area on the disk. The invention further relates to the corresponding recording devices for recording information on dual layer recordable disks using these methods.

For recordable dual-layer media (both write-once and rewritable), such as for example DVD+R disks and DVD+RW disks, that need to be read-compatible with read-only dual-layer disks, there is the issue of how to deal with an amount of data that requires a storage space occupying more than one layer of the dual layer disk, but less than two full layers.

A first recording method for recording information on such a dual layer recordable disk, method A, is depicted in the left-hand side of figure 1. In this method, first a first layer L0 is written completely full, and subsequently the remainder of the data is written on a second layer L1. A second recording method for recording information on a dual layer recordable disk, method B, is depicted in the right-hand side of figure 1. In this method according to the present invention, the data to be written is equally divided between both layers L0 and L1.

Here L0 is defined to be the layer closest to the recording lens in a recording device, and therefore also closest to the entrance surface of the laser beam in the disk. L1 is the other layer. In order to clarify this more, the layout of a dual layer DVD-ROM disk according to Standard ECMA-267 is depicted in figure 2 for a so-called OTP (Opposite Track Path) disk. As is described in this Standard, the spiral direction of layer L0 is opposite to the spiral direction of layer L1 in an OTP type disk.

In method A, first layer L0 is written from radius R_{in} to R_{out} (which are 24mm and 58mm for DVD type media). Next, the laser spot (used for recording the data in a layer) jumps from layer L0 to layer L1 and the remainder of the data is written. Depending on the

amount of data to be recorded on the disk, layer L1 is written up to a certain radius. However, in order to guarantee playback on existing DVD players (especially DVD-Video and DVD-ROM players), the remaining part of layer L1 must be written also (for example with dummy data). This because some players immediately jump from one layer to the other layer when the target of a seek command is located on the other layer. If no data would be found after the layer jump (because the location jumped to has no data recorded), the player is very likely to crash and/or report a fatal error as no tracking can be performed in the absence of data written on the disk at that location. By writing a long lead-out area, as is shown in the left-hand side of figure 1, compatibility with existing DVD players can be assured. However, this may require a long additional time needed to write the lead-out area ('finalization').

This additional time is avoided by applying the recording method B according to the present invention as claimed in claim 7. Here the data is equally divided between both layers L0 and L1, which implies a certain maximum radius R_{max} beyond which no data is written on both layer L0 and layer L1. The value of R_{max} is variable and depends on the amount of data to be recorded on the disk.

However, another problem occurs during recording. When the laser spot jumps from layer L0 to layer L1, an Optimum Power Control (OPC) procedure has to be carried out on layer L1 before the recording can proceed. As is well-known to a person skilled in the art, an Optimum Power Control procedure is a procedure for determining the actual optimum writing power for recording information on a layer of a disk. This optimum writing power depends on the disk, the recorder, and the recording speed that is actually used. Therefore, this optimum writing power should be determined for each recorder/disk combination at the actual recording speed. This Optimum Power Control procedure is generally performed in a fixed area on the disk that is specially reserved for this purpose, the so-called OPC-area.

When this OPC-area is located at the inner or outer radius of the disk, as is the case for single-layer media, first an access to that (inner or outer) radius must be carried out. This jump requires a certain amount of extra time. Especially when recording is done in CLV-mode, where a jump involves a change in disk rotation speed, a considerable amount of extra time may be required. During this extra time the data stream generally continues, which has to be captured in a memory buffer. Therefore such a buffer has to be larger than when no

jump is needed. It is noted that the OPC procedure is performed "on the fly" when switching from layer L0 to layer L1.

It is a further object of the present invention to provide a method in which the amount of extra time is reduced. This object is achieved by providing a method according to the preamble characterized in that the Optimum Power Control procedure is performed in an OPC-area variably located on at least one of the layers (L0, L1) of the dual layer disk.

The method and recorder according to the present invention imply a variable position of the OPC-area, the position depending on the amount of data to be recorded on the disk. In a preferred embodiment the method and recorder according to the present invention use an OPC-area positioned on the second layer, L1, located relatively close to the radius where the data stream switches from the first to the second layer (such as R_{max} in method B). This radius depends on the amount of information to be recorded on the disk.

In a version of the method according to the invention the OPC-area is located in the so-called Middle Zone of layer L1 in order to realize a fast "on-the-fly" OPC-procedure at the radius of the layer jump (as is shown in figure 3, where MZ0 denotes the part of the Middle Zone located in layer L0 and MZ1 denotes the part of the Middle Zone located in layer L1). This Middle Zone is defined for DVD-ROM disks in the above-mentioned Standard ECMA-267.

According to Standard ECMA-267, the Information Zone (or Data Zone) has a Middle Zone in each layer to allow the laser spot to move from layer L0 to layer L1. This is shown in figure 4. The Middle Zone can be considered as a kind of intermediate lead-out area on a dual layer disk. According to the standard, the Middle Zone extends 1mm beyond the last written location on layer L0. This is sufficient to incorporate an OPC-area. It is noted however that the OPC-area may extend beyond the 1mm boundaries of the Middle Zone.

It is noted that the present invention has the additional advantage that the optimum writing power after a layer jump may be determined more accurately. When, after a layer jump, an OPC-procedure were to be performed at the inner or outer radius of the disk, this would not lead to an optimum power control because the OPC-procedure is done at a position different from the start position of the actual recording on layer L1. The properties of the disk at the outside can vary from the properties at the actual recording position.

In a version of the method according to the invention a further Optimum Power Control procedure is performed in a fixed and reserved OPC-area. Similar to single layer disks, such an fixed OPC-area may be located at the inner radius and/or the outer radius of the disk. This further Optimum Power Control procedure may, for example, be performed

to determine an initial optimum writing power to be used when starting writing on layer L0. Furthermore, an initial optimum writing power may be determined for each of the layers individually.

Although the invention has been elucidated with reference to the embodiments described above, it will be evident that other embodiments may be alternatively used to achieve the same object. The scope of the invention is therefore not limited to the embodiments described above, but can also be applied to all kinds of recordable media (both write-once and rewritable), such as for example DVD+R, DVD+RW, DVD-R, DVD-RW, DVD-RAM, and Blu-ray Disk.

Furthermore, in the embodiments described above the invention is explained by writing data first to layer L0 and subsequently to layer L1. However, it should be noted that the invention works equally well when data is written first to layer L1 and subsequently to layer L0. Moreover, the scope of the invention is not limited to dual layer disks only, but can be applied on multiple layer disks consisting of more than two layers for storing data as well.